SOIL VARIABILITY ON GOLF COURSES: THE CASE FOR BETTER INFORMATION

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Soil is the foundation of all forms of agriculture. There are a few exceptions, such as the hydroponic production of certain vegetables, but by and large the quality of the soil in which a crop is grown determines the yield and quality of the product.

Turf is no exception. The product course managers and greenkeepers strive for may be different compared to other crops. Quality and consistency of the turf surface are the criteria against which greenkeepers are judged instead of yield and produce quality, but the role of soils in the production of turf is just as important.

QUALITY SOILS COMBINED WITH SOUND MANAGEMENT PRODUCE QUALITY TURF

Soil quality on golf courses is often less than optimum. Soils are considered less important in the overall function of a golf course compared to other forms of agriculture. In golf the focus is on the overall quality of the landscape and on the experience of playing the course.

The connection between soil and turf quality is not made as strongly as with other crops. Golf holes are designed and built to make the game challenging and interesting. The aesthetic quality of a golf course is central to the overall experience. Golf courses are often considered works of art like other designed landscapes.

But the process of building a golf course can be damaging to soils. Typically, large volumes of earth are moved to create the right experience. Topsoil is stripped off and stockpiled, landforms are created through cutting and filling and the topsoil is reapplied and graded.

The construction process can dramatically alter the original soils on a site by destroying structure, creating compaction in the rooting zone and in subsoil layers, and generally disrupting natural processes that keep soils healthy.

Following construction, routine management practices combined with traffic from golf carts and foot traffic exert significant stress on soils. In addition, the use of a variety of chemicals and the tendency to over-water, keeping the root zone wet, can alter microbial processes critical for sustaining soil health.

Treating soil problems on golf courses is difficult since soils under turf are less accessible and are more difficult to modify compared to other agricultural soils. Since turf is a long-term perennial crop, soils are exposed only during initial construction or renovation.

Most agricultural soils are exposed every year or every few years, making cultivation or modification easier. In addition, what's judged as the product of the greenkeeper's efforts, a uniform, consistent, high quality surface, discourages any activity that disrupts the turf. Dealing with soil problems in turf management is a major challenge.

An added complication related to soils is the issue of variability in factors that influence fertility, aeration, water-holding capacity, drainage and susceptibility to compaction. Soil texture, or the relative amounts of sand, silt and clay, and stable soil organic matter strongly influence these qualities.

A knowledge of how soil conditions change across a golf course is central to a greenkeeper's ability to efficiently apply irrigation, fertilizers and cultivation treatments such as aerification.

Because turf is a perennial cover, the ability to see differences in these characteristics based on soil colour or other visual clues that are often used to judge variability in agricultural fields is limited.

With increasing pressure to reduce overall inputs of chemicals and water, and to manage labour and equipment more cost effectively, golf course managers and greenkeepers need more detailed information on how soils vary across their courses.

All things considered, the importance of maintaining healthy soils is indisputable in growing healthy turf. But greenkeepers are confronted with a range of soil problems brought about by the way golf courses are constructed and how the golf turf is used and maintained.

The inability to get at soils under turf only complicates the issue. And the increasing importance of efficiently applying water, nutrients and other inputs that are affected by soil conditions increases the importance of detailed soils information that is rare in the industry.

A study is underway at The Toro Company to analyse and map soils on a variety of golf course fairways to gain a better understanding of the inherent variability in conditions that typically exist.

Toro's specific interest is in the efficient control of irrigation in response to increasing pressure to conserve water in golf course management. Understanding soil variability in detail is a key to this objective. Significant variation in soils is assumed to exist on golf courses, but very few have detailed soils information quantifying this variation.

Therefore the objective of the study is to quantify soil variability in order to better understand how changes in soil conditions across large areas such as fairways affect turf management practices.

A number of golf courses have been chosen for mapping and they represent a range of several factors that ultimately have an affect on soil conditions, as follows:

1. **The amount of disturbance during construction**
2. **The amount of topographic and corresponding soil variation indigenous to the site**
3. **The age of the golf course**

The assumption is that soil conditions on a course are influenced to a significant degree by these factors. For example, a course built on undulating terrain and modified little during construction would be expected to have considerable variation in soils corresponding to patterns native to the site.

On the other hand, a course whose soils were heavily modified from grading during construction may have less variation in surface layers due to the homogenizing effects of stripping and reapplying, but may have significant differences in the subsurface layers resulting from cutting and filling.

The results presented here are from a single fairway on an 80-year-old golf course in the upper Midwestern United States, illustrating the significant variation in soil conditions that can exist from undulating terrain that was modified little during construction.

Midland Hills Golf Course is located in Roseville, Minnesota, in a naturally rolling and intermittently wooded landscape. The original nine holes of the golf course were built in the 1920s with the second nine added in the 1950s. Minimal earth-moving was done during construction of the fairways, taking advantage of the rolling natural landscape.

▲ Aerial view of the 14th fairway at Midland Hills Golf Course

▲ A view of the 14th fairway showing its undulating terrain

As a result, the existing topography and soils are assumed to reflect original conditions. The native soils for the Midland Hills' site as described in the United States Department of Agriculture Soil Survey of Washington and Ramsey Counties, Minnesota, are made up of the Mahtomedi-Kingsley complex (loamy sands), the Hayden Series (fine sandy loam) and the Duluth Series (silt loam), all derived from glacial till.

Soils were sampled on a 9m grid to a depth of 45cm in 15cm increments (0-15cm, 15-30cm and 30-45cm). A portable GPS unit was used to record location data at each sampling point for mapping purposes.

Soil texture was analysed in the Toro agronomic laboratory using conventional methods and recorded as percentages of sand, silt and clay. Organic matter content was also analysed in the laboratory using standard methods.

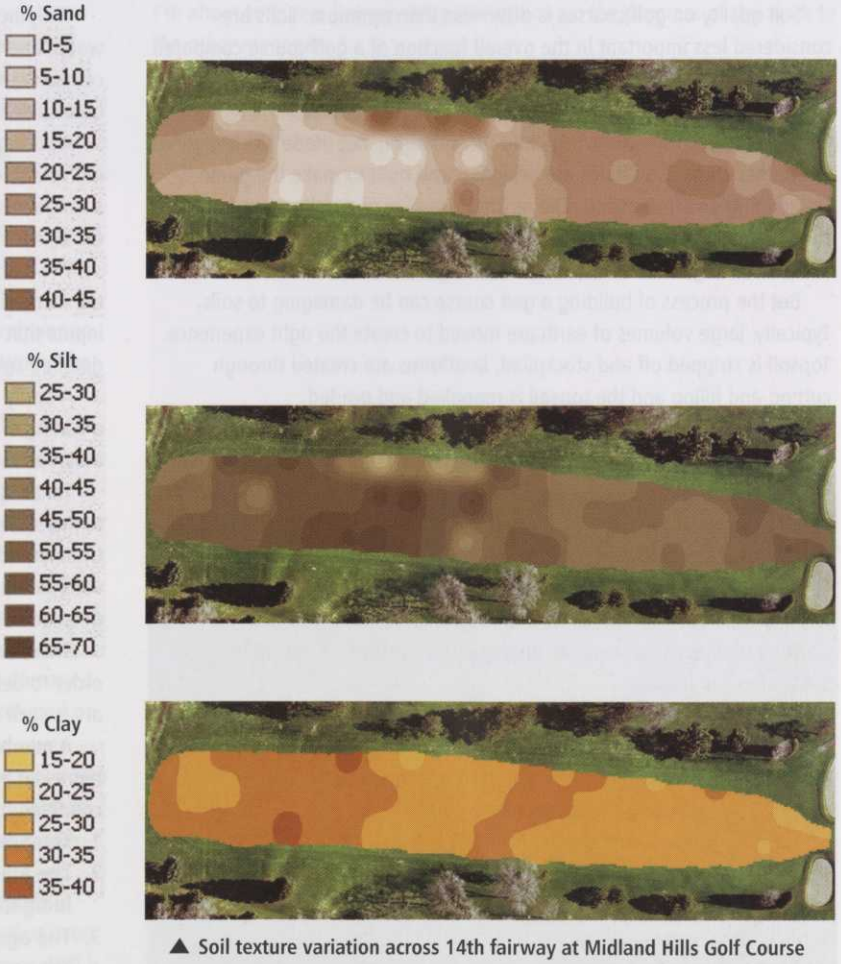
Soil compaction was measured on site using a hydraulic penetrometer. Compaction was quantified as resistance to penetration in psi at 2.5cm increments to a depth of 45cm.

All mapping was done using GIS software (ArcGIS Desktop version 8.3.0 with Spatial Analyst Extension). The maps shown here for the 14th fairway at Midland Hills illustrate variations in each factor using a colour gradient. Only maps for the top 15cm are shown since this layer represents the rooting zone.

Soil texture in the top 15cm was generally classified as silty clay loam. There was considerable variation across the fairway in each component. Sand ranged from approximately 5 per cent to 40 per cent, silt from 30 per cent to 65 per cent, and clay from 23 per cent to 38 per cent. There was a two-fold difference in organic matter in the top 15cm ranging from 3 per cent to 6 per cent.

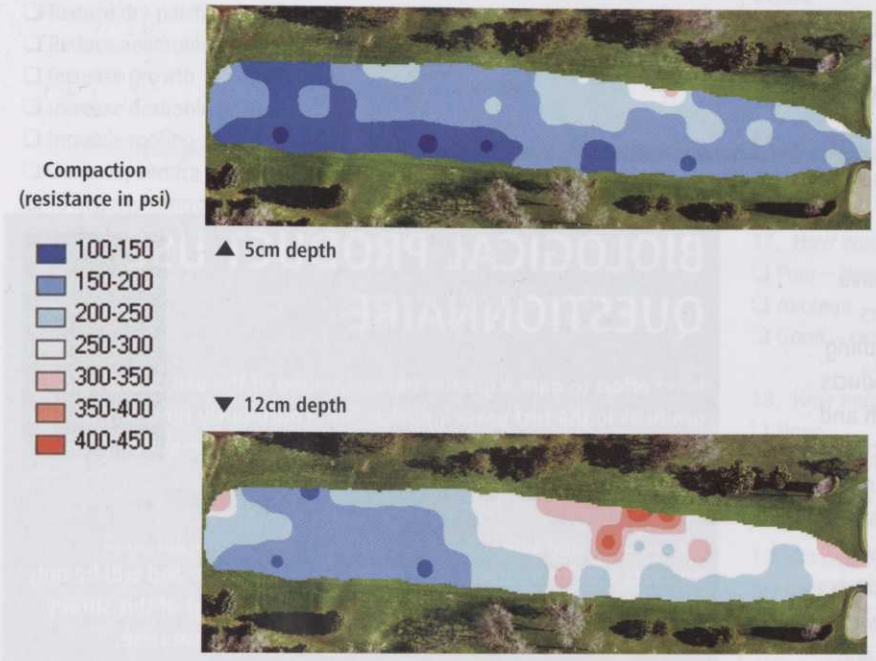
Soil texture corresponded to topography to some degree, with heavier soils concentrated in a major swale through the middle of the fairway and coarser soils concentrated on high points and in a flat area of the fairway nearer the green.

Soil compaction varied across the fairway surface as well as by depth. The greatest levels of surface compaction



▲ Soil texture variation across 14th fairway at Midland Hills Golf Course

▲ Organic matter variation across 14th fairway at Midland Hills Golf Course



▲ 5cm depth

▼ 12cm depth

▲ Soil compaction at 5cm and 12cm. Greater compaction at 12cm occurs just below tine aerification depth, creating a cultivation pan

were located in the landing area of the fairway, which receives the most golf cart traffic. There was no clear relationship between soil texture and surface compaction.

The highest level of compaction by depth was concentrated at 12 to 15cm indicating the presence of a cultivation pan just below tine aerification depth. Deep tine aerators, which are becoming increasingly popular, are designed to penetrate this deeper layer of compaction.

All of this information together verifies the fact that considerable variation in soil characteristics such as texture, organic matter and compaction can exist across large turf areas such as golf course fairways.

It also indicates that the extent of soil variation may dramatically affect the way different areas are managed. A fairway's soils from one end to the other may have significantly different capacities to retain nutrients and water and to resist compaction.

A detailed knowledge of soils in a case such as this could help the course manager and greenkeeper to design more effective treatment programmes on a site-specific basis. If soils are at the heart of growing healthy turf, then the more they know about them the better the job they can do.